

DEVICE FOR DENTAL CARE AND WHITENING

CROSS-REFERENCE TO RELATED APPLICATIONS

- 5 This application claims the benefit of U.S. Provisional Application Number 60/249,015, entitled DEVICE FOR DENTAL CARE AND WHITENING, and filed November 15, 2000, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

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1. Field of the Invention

This application relates to dental hygiene, and in particular, relates to devices and methods for exposing teeth to electromagnetic radiation.

15 2. Description of Related Art

- Dental hygiene is important for dental health and for personal appearance. People often desire to have whiter or cleaner teeth. A number of different devices and methods are known in the art for whitening and cleaning teeth. Several methods utilize a whitening agent, such as peroxide, alone or in combination with other agents, to attempt to whiten teeth. In certain processes, the whitening agent is applied to teeth by brushing the teeth with a dentifrice, such as a paste, gel, liquid, cream, or powder, containing the whitening agent. Other methods employ dental trays or dental stints that have received an application of a whitening agent. In such methods, the dental tray is pressed onto the teeth, and the whitening agent is permitted to bathe or coat the teeth (e.g., see U.S. Patent No. Re. 34,196, entitled METHOD AND
- 20 MATERIAL FOR BRIGHTENING TEETH). Another method employs a dental tray having a heating element wire disposed within the tray (e.g., see U.S. Patent No. 6,102,705, entitled HEATED DENTAL TRAY). In that method, a whitening agent is applied to a dental tray having a heating element wire, and the tray is pressed onto the teeth of a person. Current then passes through the wire and heats the teeth. In yet another method, lasers are used to enhance
- 25 the effects of whitening agents (e.g., see U.S. Patent Nos. 6,254,388, entitled METHODS FOR WHITENING TEETH; and 6,155,832, entitled METHODS AND APPARATUS FOR
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WHITENING TEETH). In U.S. Patent No. 6,254,388, argon laser energy is manually directed over a person's tooth. The soft tissues of the mouth, such as the gums, is protected by rubber dams or adhesive wax. In U.S. Patent No. 6,155,832, laser light is manually directed and used to activate whitening agents provided on dental tape.

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Currently known devices and methods may suffer from the problem that the effectiveness of the whitening agent is not maximized, or that the use of lasers requires manual guidance over each tooth in order to achieve the desired whitening. Accordingly, there remains an unmet need for a device that provides substantial whitening or cleaning of teeth and eliminates the need for manually guiding an energy source over the teeth.

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SUMMARY OF THE INVENTION

The present invention provides a device and methods for exposing teeth to electromagnetic radiation. The devices and methods improve dental hygiene, and may enhance the cosmetic appearance of teeth.

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The dental device of the invention broadly includes a carrier, and at least one electromagnetic radiation source. The carrier may include, but is not limited to, dental trays, dental bands, and/or dental tape. The electromagnetic radiation source may be a light source. The energy emitted from the electromagnetic radiation source may have one or more wavelengths between the ultraviolet light spectrum and the infra-red light spectrum. The radiation may activate hygienic or cleaning agents provided in dentifrices.

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The dental device of the invention may also include a power supply to power the electromagnetic radiation source, and/or may include a circuit for controlling the electromagnetic radiation source(s).

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A dental device for exposing teeth to electromagnetic radiation may include a carrier to be applied to at least one tooth; and one or more light sources attached to the carrier and oriented

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so electromagnetic radiation is emitted from the light source or sources toward a tooth surface.

The carrier of the foregoing device may be a dental tray, a dental band, or dental tape. The light source may be a light emitting diode, an optical fiber, or an electrochemiluminescent material. The optical fibers may be provided as an optical fiber panel.

A dental device for exposing teeth to electromagnetic radiation may also comprise a dental tray structured to fit over the teeth of a subject; and a plurality of optical fibers to provide electromagnetic radiation to at least one tooth. The optical fibers can be disposed on the dental tray so that the electromagnetic radiation is directed to at least one tooth. The optical fibers may define an optical fiber panel.

The foregoing devices may also include a power source in communication with the light source. The power source would provide power to the light source so that the light may be emitted from the light source. The foregoing devices may also include one or more circuits for controlling the electromagnetic radiation emitted from the light source. In addition, the foregoing devices may include one or more panels, including a reflective panel, a diffuser panel, and/or one or more transparent panels. The panels may contribute to the structure of the light source arrays, and may enhance or improve the effects of the electromagnetic radiation. The reflective panel may be positioned between the light source and the carrier. The diffuser panel may be positioned over the light source so that light emitted from the light source passes through the diffuser. The transparent panel may be provided over the light source, and/or may be provided between the light source and the carrier. The foregoing devices may also include an optical fiber bundle operably connected with the light source so that optical energy may be transmitted from the optical fiber bundle to the light source.

A method for exposing teeth to electromagnetic radiation comprises the steps of: (a) providing a dental device, which comprises a carrier and a plurality of optical fibers disposed on or in the carrier; (b) applying a dentifrice containing an agent having cleaning properties, the cleaning activity of the agent activated by electromagnetic radiation provided by the

optical fibers to the dental device; (c) applying the dental device to a subject's teeth; and (d) activating a power source so that electromagnetic radiation is emitted from the optical fibers toward the dentifrice and the subject's teeth. The carrier used in the foregoing may be a dental tray.

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Any feature or combination of features described herein are included within the scope of the present invention provided that the features included in any such combination are not mutually inconsistent as will be apparent from the context, this specification, and the knowledge of one of ordinary skill in the art.

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Additional advantages and aspects of the present invention are apparent in the following detailed description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

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FIG. 1 is a perspective view of a dental device in accordance with the present invention.

FIG. 1A is a top plan view of the device illustrated in FIG. 1.

20 FIG. 1B is a top plan view of the device illustrated in FIG. 1, showing light emitting diodes spaced relatively close together.

FIG. 1C is a top plan view of the device illustrated in FIG. 1 without a transparent panel covering light emitting diodes.

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FIG. 1D is a portion of a top plan view of the device illustrated in FIG. 1 showing a transparent panel, light emitting diodes, and a light source panel.

30 FIG. 1E is a portion along box 1E of FIG. 1A showing a transparent panel, light emitting diodes, a light source panel, and a reflective panel.

FIG. 1F is similar to FIG. 1E but showing two transparent panels, light emitting diodes, a light source panel, and a reflective panel.

FIG. 1G is similar to FIG. 1F showing a diffuser panel disposed between one transparent
5 panel and the light emitting diodes.

FIG. 2 is similar to FIG. 1D without the transparent panel, and showing the use of side mounted contacts.

10 FIG. 3 is similar to FIG. 2 showing surface mounted contacts.

FIG. 4A is similar to FIG. 1 depicting a perspective view of the device of the invention having a fiber optic bundle and an internal electromagnetic radiation source.

15 FIG. 4B is similar to FIG. 4A illustrating an embodiment of the device of the invention in which the electromagnetic radiation source is externally located.

FIG. 4C is a top plan view of the device of FIG. 4A depicting a transparent panel, a diffuser, an optical fiber panel, and a reflective panel.

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FIG. 4D is similar to FIG. 4C but depicting a transparent panel, an optical fiber panel, a light source panel and a reflective panel.

FIG. 4E is a portion of a top plan view of the device of the invention depicting a transparent
25 panel and an optical fiber panel.

FIG. 4F is a portion of a top plan view of the device of the invention depicting a transparent panel, an optical fiber panel, and a reflective panel.

30 FIG. 4G is a portion along the box 4G of FIG. 4C depicting a transparent panel, a diffuser panel, an optical fiber panel, and a reflective panel.

FIG. 4H is a portion of a top plan view of the device of the invention depicting two transparent panels, a diffuser panel, an optical fiber panel, and a reflective panel.

- 5 FIG. 4I is a portion along the box 4I of FIG. 4D depicting a transparent panel, an optical fiber panel, a light source panel, and a reflective panel.

FIG. 5 is a perspective view of the device of the invention having a dentifrice cartridge connected to the device.

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FIG. 6 is a perspective view of the device of the invention having an aspirator connected to the device.

- 15 FIG. 7A is a side elevational view of the device of the invention in which the device is a dental band or dental tape disposed on teeth.

FIG. 7B is a sectional view along line 7B-7B of FIG. 7A.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

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Although the disclosure herein refers to the use of a dental device for whitening teeth, the device is not limited to such uses and may be used for any dental hygienic purpose that may benefit from the application of electromagnetic energy.

- 25 The device of the invention generally includes a carrier, such as a dental tray, a dental band, or a dental tape, or other similar device, and one or more electromagnetic radiation sources that can emit electromagnetic radiation toward the surface of one or more teeth. The electromagnetic radiation, especially when combined with a dentifrice, such as a paste, gel, cream, or powder, may improve dental hygiene, for example by whitening teeth, reducing
30 bacteria, inhibiting caries, preventing tooth demineralization, etching tooth enamel or dentin, and other similar methods.

The device of the invention may also be provided with a circuit, and/or microprocessor, for controlling the electromagnetic radiation sources. The device may also include one or more power supplies for providing energy to the electromagnetic radiation sources.

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As used herein, electromagnetic radiation or electromagnetic energy refers to monochromatic or polychromatic radiation or energy. In a preferred embodiment, electromagnetic radiation refers to light radiation or light energy. The electromagnetic radiation preferably increases the reaction rate of photosensitive agents, such as teeth whitening agents. In accordance with one aspect of the present invention, the electromagnetic radiation may be substantially free from ultraviolet radiation. In addition, the wavelengths of the electromagnetic radiation may be provided between approximately 300 and 990 nanometers, or up to about 1 μm . Any suitable means may be used to generate the electromagnetic radiation. For example, a semiconductor laser may be implemented to generate monochromatic electromagnetic radiation, or a light emitting diode (LED) may be configured to emit polychromatic electromagnetic radiation. A non-limiting example of a laser source may comprise a Nd:YAG laser, although various other lasers having various wavelengths in the UV, visible and IR spectrum, for example, may be implemented individually or in combinations.

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Referring more particularly to the illustrated embodiments, FIG. 1 provides a perspective view of a dental device 10. As illustrated in FIG. 1, dental device 10 comprises a dental tray 12 configured to fit over a person's teeth. For example, dental tray 12, as shown, may fit over a person's upper teeth. Dental trays are well-known in the art. Dental tray 12 may be generic or custom designed. The dental tray will fit within a person's mouth, and may cover all of the upper or lower teeth or a portion thereof. In certain embodiments, one dental tray may fit over both the upper and lower teeth, such as a mouth guard typically worn by athletes. In the illustrated embodiment, dental tray 12 includes a tooth bed 14 positioned between an outer sidewall 16 and an inner sidewall 18. Teeth are intended to be placed into tooth bed 14. Outer sidewall 16 will accordingly be disposed between the outer surface of the teeth and a subject's cheeks, and inner sidewall 18 will be disposed between the inner surface of the subject's teeth and the mouth cavity.

Dental trays may be manufactured from any suitable material including rubbers and plastics, including, but not limited to polyethylenes, polypropylenes, and ethyl vinyl acetates. Dental trays may be manufactured in any conventional method. For example, a custom dental tray
5 may be made by making an impression of a subject's teeth, and may be vacuum or thermoformed over the impression. Dental trays designed to simultaneously fit over the upper and lower teeth may include through holes to provide an air passage so that the wearer of the dental tray may breathe.

10 As shown in FIG. 1A, dental tray 12 includes an electromagnetic radiation source 20, such as LEDs 22. LEDs 22 are perimetrically disposed along the interior of the outer sidewall of the dental tray so that energy emitted from the LEDs will be emitted toward the outer surface of a subject's teeth. In the illustrated embodiment, LEDs 22 are attached to light source panel 24. Thus, LEDs 22 are provided as a strip or array of LEDs embedded, molded, mounted, potted,
15 or otherwise bonded on or within the tray. The LED array may include side-mounted LEDs (FIG. 2), surface-mounted LEDs (FIG. 3), or a combination of surface- and side-mounted LEDs. An example of one suitable LED is the publicly available 1005 Series of LEDs from Marktech Optoelectronics (Latham, NY, USA).

20 Although LEDs are illustrated as the electromagnetic radiation source in FIGS. 1-3, other electromagnetic radiation sources may also be used. Examples of other electromagnetic radiation sources include, but are not limited to, heat emitting elements, chips from and LED, lasers or laser diodes, arc lamps, incandescent lamps, halogen lamps, neon lamps, and/or fluorescent sources. The electromagnetic radiation sources may emit electromagnetic
25 radiation from ultraviolet to visible to infra-red light. In one embodiment, infra-red spectral energy may be preferred.

LEDs 22 may be covered by a relatively clear or transparent material. The transparent material may be provided as a transparent panel 28 disposed between LEDs 22 and the outer
30 surface of the teeth, as shown in FIG. 1A. However, the transparent material may also be the surface of the dental tray, and not comprise a separate transparent panel, as shown in FIG. 1C.

The transparent material should be flexible and moldable so that the panel may conform to the curvatures of a person's mouth. The transparent material should also emit most of the light from the electromagnetic radiation source to the teeth surface. One example of a suitable transparent materials is moldable, flexible plastic. Transparent panel 28 may be molded, embedded, or attached to the dental tray over light source panel 24. Transparent panel 28 may also protect the LEDs from damage. In addition, a clear resin 26 may be provided between transparent panel 28 and LEDs 22 to provide additional support and protection.

The light sources, such as LEDs 22, may be provided at some predetermined distance, for example, one LED per tooth, or may be provided relatively close together, such as illustrated in FIG. 1B. The particular spacing of LEDs 22 is determined and is chosen to optimize the desired whitening or cleaning activity provided by the electromagnetic radiation emitted from the LEDs.

FIG. 1D depicts a portion of dental tray 22 in which the dental tray includes a light source panel 24 covered by a transparent panel 28. The effectiveness and efficiency of the emitted electromagnetic radiation may be enhanced by adding a reflector, such as reflective panel 34, positioned against the non-illuminated side of light source panel 24 (e.g., FIGS. 1E to 1G). Any suitable reflector may be used including mirrors and foils. The reflector should be made of a material that causes most, if not all, of the light to be reflected back toward the tooth surface. FIG. 1F shows a portion of a dental tray having one transparent panel 28 over light source panel 24, and another transparent panel 28 positioned under reflective panel 34. This additional transparent panel may provide additional protection and structure to the light source panel. In FIG. 1G, a diffuser panel 32 is shown disposed between the light emitting side of light source panel 24 and transparent panel 28. Diffuser panel 32 acts to diffuse the light and provide a more uniform emission of light toward the tooth surface. In addition, diffuser panel 32 may be a polarizer causing a separation of wavelengths of light, especially in devices employing polychromatic light sources.

As shown in FIG. 2, when side-mounted LEDs are utilized, contacts 30 extend into light source panel 24. When surface-mounted LEDs are utilized (FIG. 3), contacts 30 are provided on the surface of light source panel 24.

5 FIG. 4A illustrates dental device 10, such as a dental tray 12, which includes electromagnetic radiation source 20. In the illustrated embodiment, electromagnetic radiation source 20 is internally disposed within dental tray 12. The illustrated embodiment also includes an optical fiber bundle 44 extending into electromagnetic radiation source 20. FIG. 4B illustrates a dental device 10 similar to the dental device of FIG. 4A, except that the electromagnetic
10 radiation source is externally positioned with respect to dental tray 12. Accordingly, optical fiber bundle 44 is disposed between electromagnetic radiation source 20 and dental tray 12. Optical fiber bundle 44 acts to direct light from an energy source to one or more optical fibers, described herein.

15 The dental devices of FIGS. 4A and 4B utilize a light source panel 24 which comprises one or more layers of optical fibers 42 (FIGS. 4C and 4D) or fiber optic pipes. The optical fibers may be woven together. Multiple layers may provide more efficient use of the energy from the electromagnetic radiation source, and may enhance the brightness and uniformity of the light emitted from the light source panel to the target area (e.g., the dentifrice and teeth). The
20 panel of woven optical fibers may be molded or embedded in the dental tray. In another example, light may be emitted from a single side of the panel with a relatively high intensity, and a reflective panel may be provided attached to the outer layer of woven optical fibers. Similar to the embodiment of FIG. 1, a diffuser panel may be provided to increase the uniformity of the light on the tooth surface. One example of a suitable optical fiber panel is
25 the Lumitex® panel (Lumitex, Inc. Strongsville, Ohio, USA), as disclosed in U.S. Patent No. 5,613,751, entitled LIGHT EMITTING PANEL ASSEMBLIES, the contents of which are hereby incorporated by reference.

FIG. 4E illustrates one device of the invention in which an optical fiber panel 42 is covered by
30 transparent panel 28. FIG. 4F shows a similar device, but one that includes reflective panel 34. FIG. 4G shows a portion along box 4G of FIG. 4C in which diffuser panel 32 is disposed

between transparent panel 28, and optical fiber panel 42. FIG. 4H is similar to FIG. 4G showing an additional transparent panel 28 below reflective panel 34. FIG. 4I is taken along the box 4I of FIG. 4D, illustrating a light source panel 24 below optical fiber panel 28.

5 In using the foregoing devices of the invention, a dentifrice, including, but not limited to pastes and gels, is placed in the dental tray, and the tray with the dentifrice is fit over the upper or lower teeth. The electromagnetic radiation sources are then activated, and the tray is kept in the mouth for a predetermined duration. The dentifrice will typically contain one or more active ingredients depending on the particular application. For example, the dentifrice
10 may include one or more of the following compounds: peroxy compounds (such as, hydrogen peroxide and/or carbamide peroxide), oxidoreductase agents (such as laccases, oxidases, and/or peroxidases), antibacterial agents (such as chlorhexidine digluconate, hexetidine, alexidine, quarternary ammonium and water-soluble sources of certain metal ions such as zinc, copper, silver, and stannous), anti-carries agents (such as fluoride), anti-plaque agents or
15 plaque control activators, anti-tartar agents, desensitizing agents, etching agents (such as phosphoric acid), photosensitizers and photodynamic therapy photosensitizers, whitening agents, or pigments. Peroxy compounds may be preferred for teeth-whitening applications. In certain embodiments, the dentifrice may be placed in the tooth bed of the dental tray.

20 The dental tray of the invention may also include one or more attachments to deliver the dentifrice from a cartridge 50 through a cartridge channel 52 directly into the tray (FIG. 5). The same attachment, of a different attachment, can be used for connecting an aspirator 60 to aspirate the dentifrice through aspirator channel 62 from the dental tray after the procedure is performed (FIG. 6).

25 In other embodiments of the invention, the dental trays may include a separate compartment to be aligned with a subject's gum line. Such a compartment may serve to contain an isolating gel that protects the gums from contact with the active ingredients of the dentifrice. The isolating gel may also include a thermal insulator that may help prevent heat transfer from the
30 tray and/or the dentifrice to the gums. In addition, the dental tray could be structured to accept gel only on the side of the teeth requiring treatment, for example, the front side. The

dental tray could include two or more sub-trays inside the main tray that provide selective treatment on different groups of teeth at the same time. For example, one sub-tray could be used for a fluoride treatment of the back molars, and another sub-tray could be used for whitening the front teeth. Thus, the device of the invention may include one or more
5 compartments to customize the application of the device. The compartments may permit selective procedures to be performed on desired regions of the teeth or mouth, and/or may help protect sensitive areas of the mouth.

The dental tray may also be constructed to emit heat. This may be in addition to, or instead
10 of, the electromagnetic radiation source. For example, a dry chemical heat-emitting material may be incorporated or added to the tray. The emission of heat may be activated after the user places the tray on his teeth and the user starts biting down on the tray. One example of a suitable chemical is sodium acetate trihydrate. In certain embodiments, the heat source is incorporated into the tray so that the subject wearing the dental tray does not ingest the heat
15 source.

FIG. 7A depicts dental device 10, such as a dental band or dental tape 72 attached to a person's teeth. In the illustrated embodiment, dental tape 72 is illustrated as a plurality of intersecting lines. The cross-section along line 7B-7B is shown in FIG. 7B. Dental tape 72
20 includes an electromagnetic radiation source 20. Dental tape 72 may also include one or more compartments 50 containing a dentifrice with an active ingredient sensitive to electromagnetic radiation. Each tooth of the subject may be covered by one or more of the compartments. A protective layer 74 may be provided over compartments 50 to prevent leakage of the dentifrice from the compartments. Protective layer 74 may be peeled off before applying the
25 tape to the teeth. Alternatively, the protective layer may be made of a material subject to degradation by enzymes contained in a subject's mouth, where the enzymes dissolve the protective layer and thereby permit the dentifrice to be applied to the teeth. The electromagnetic radiation source may comprise a thin layer of woven optical fibers (e.g., Lumitrex), similar to that discussed above, a thin layer of LEDs, or even an organic or
30 polymeric thin-film of luminescent material.

Examples of potential compounds or agents used in organic or polymeric thin-film luminescence include, but are not limited to, end-capped oligothiophenes, tris-chelated polypyridyl ruthenium (II) complexes, polyphenylenes, doped tris-8-(hydroxyquinoline) aluminum, indium tin oxides, polyfluorenes, vinylene-bridged triphenylamine dimers, rhodamine 6G, bicarbazyles, 1,1,4,4-tetraphenyl-1,3-butadiene-doped polymeric Langmuir-Blodgett films, inorganic CdSe nanocrystals, carbazole-substituted polyacetylenes

The electromagnetic radiation source provided with the carrier in the dental device of the invention may be powered by any suitable means that can cause electromagnetic radiation to be emitted from the source or sources. For example, the dental tray electromagnetic radiation source may include one or more batteries, or an electrical power cord plugged into an electrical outlet. Batteries may be embedded in the tray or external to the tray. Dental tape may be provided with batteries placed within the tape, or may be able to be charged using a charging device.

The device of the invention may also include a programmable microprocessor, which may control parameters such as light, wavelength, brightness, power, or duration of emission. The parameters may be programmed as presets, or may be operated manually by the user. For example, the user may control the speed of whitening by selecting the wavelength, the brightness, the power, and the time of exposure. For in-office procedures, a clinician may decide the specific parameters suited for the patient. For out of office procedures, such as home use, the user may select one of the preset programs. For example, a program providing a higher light intensity for a relatively short duration. In addition, the dental device may include a sensor device that, through software control, would let the user know when the process is completed or the treatment time has expired.

Thus, the dental device of the invention is easy to use, and may provide fast and effective treatment over conventional devices. The dental device of the invention may provide selective treatment for specific tooth surfaces, and better alignment and a more controlled, uniform treatment. The device may reduce tooth sensitivity. The device may require less time for wearing the device, and may reduce discomfort associated with whitening agents

contacting the teeth for a long period of time. The device provides means for treating teeth or portion of teeth locally. The clinician is not required to point the electromagnetic radiation source to every tooth, as is conventionally done.

- 5 While this invention has been described with respect to various specific examples and embodiments, it is to be understood that the invention is not limited thereto and that it can be variously practiced with the scope of the following claims.